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HISTORY

OF

THE DISCOVERY

OF THE

Circulation of the Blood.

A LECTURE

BY

CHRISTOPHER JOHNSTON, M. D.

PROFESSOR OF ANATOMY,

University of Maryland.

PUBLISHED BY THE CLASS.

BALTIMORE:
PRINTED BY WILLIAM K. BOYLE.
1867.

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LECTURE.

GENTLEMEN:

It is not easy for you, at the present day, to appreciate the difficulties which beset the path of the older Anatomists and Physiologists. The field of science was wide, much of it was untrodden; and theory took the place of experimentation and observation. There was more faith in men than in the age in which we live; and a *dictum*, with a great name attached, passed current for truth in spite of palpable evidence. Now-a-days doctrine is not accepted in virtue of any name, but in consequence of the kind and amount of evidence by which it is supported.

Again, before the time of Vesalius human anatomy was not largely cultivated by dissection of the human body, nor permitted to be practically taught in public. Wherefore, the so-called facts in human Anatomy were, in the main, inferential, and were originally derived from other and lower animals than man

In our day, in the broad sunshine of the Physiology of observation and experiment, we wonder at the antiquated inductive Physiology; but we take no account of the spirit of a former age, and the very limited means of observation.

To understand what was dimly perceived or misapprehended, let me first express the modern and established view of the Circulation of the Blood, and then we may, with more advantage, follow up the day from its dawn.

The adult circulatory apparatus in Mammalia—man being at the head of this class—consists of

1st. A *double* central and hollow muscular organ; and

2d. Ramified contractile and elastic tubes, communicating by their finest subdivisions at the periphery everywhere, and with the central organ by large trunks.

The central organ, or Heart, is divided into four chambers, two being recipient and two propelling cavities. These are associated in pairs, consisting of one of each kind, placed one above the other, and constitute *single hearts*, entirely independent of each other, and *not communicating*, although the two hearts are mechanically bound together. The single hearts are named from their position *right* and *left*, or *venous* and *arterial* from the kind of blood they respectively receive and transmit.

Theoretically the two hearts are adherent along their contiguous sides; in fact, the inter auricular and inter ventricular septa are single, are common to the related chambers which they sunder, and are complete and imperforate.

The opening between the auricle, or recipient cavity, and the ventricle, or propelling cavity, of each single heart, is guarded by membraneous valves which prevent retrocession of the circulating fluid into the auricle, and the orifice of each large arterial trunk, aorta and pulmonary artery, is equally provided with valves. And in afferent vessels, or *veins*, valves are placed at intervals and open *towards* the heart.

When the heart is in action the auricles fill, propel the blood simultaneously into the ventricles, which force it onwards through the lungs and into the system at large.

Blood, arriving from the system, reaches the right ventricle which projects it into the lungs, and returning to the heart arterialized or oxygenized, enters the left auricle. This circuit is known as the lesser or pulmonary circulation.

Pressed onwards the blood fills the left ventricle, which, contracting, urges it into the aorta, whence it passes through the capillary vessels and veins, and returns to the right auricle. This circuit, including the portal circulation in a parenthesis, is the greater or systemic circulation.

We will now turn back to Antiquity.

The discovery of the Circulation of the Blood does not belong, and can, indeed, hardly belong to one man, or to one epoch. Many errors had to be refuted; and for each error a truth had to be substituted. This was done; but it was accomplished successively, slowly, little by little.

Three principal errors concealed the great fact of the Circulation of the Blood.

1st. That the arteries contained *air* only;

2d. That the inter ventricular septum was perforated; and

3d. That the veins carried *Blood to* all parts of the body, instead of bringing it back from them.

Before *Galen* (Second Century) it was believed on the authority of Eristratus, that *air*, *attracted* by the Lungs, reached them through the *aspera arteria*, trachea or coarser *air-tube*. Thence the air passed into the pulmonary veins, from these into the left ventricle; and from the left ventricle it passed into the arteries, or air-tubes, which distributed it to the system.

Whence an arterial or air system; and, as the *Veins* alone contained *Blood*, a venous or *sanguiferous system*.

Galen, by experiment, refuted one grand error. "If we open an *artery*," says he, "*Blood* issues, and as no *air* escapes, the arteries contain Blood."

He intercepted a portion of an artery, incised the included part, and found Blood, but *no air*, to flow out. Wherefore the arteries contain Blood only.

The lungs attract air, and respiration serves to refresh the blood.

Galen believed, however, that the ventricular septum was perforated, and that the veins carried the blood into the system.

That there were two sorts of Blood, the *spirituous*, nourishing such delicate organs as the *Lungs;* and the *Venous*, nourishing such gross organs, as the Liver.

The *pure spirit* was generated in the Left Ventricle, but a portion passed through the septal pores into the venous Blood of the Right Ventricle.

He also taught that *arterial pulsation* was due to a *pulsific virtue* in the arteries, derived through their tunics from the heart.

But his great doctrine was that the *chyle* was taken up by the intestine veins, carried by them into the *Liver*, (towards the centre!) and there changed into Blood. The Liver then, was the organ for the conversion of *chyle* into *Blood*, the organ for the conversion of *black blood* into *red blood*. The Liver was, in fact, the organ of SANGUIFICATION.

And to complete a symmetrical physiology, Galen maintained that the *Brain* is the origin of all the nerves; the *Heart*, the origin of all the arteries, and the *Liver*, the origin of all the veins.

For nearly fourteen hundred years these same doctrines held ground *even in the face* of direct observation, against which it was thought sufficient to assert "Dixit Galenus." Even Andreas Vesalius, after satisfying himself of the non-existence of the assumed inter-ventricular *foramina*, speaks of the passage of blood through them, as he says, to accommodate himself to the dogmas of Galen.

But, at length, unable any longer to resist the truth, he affirmed that the septum was *not* perforated; and a *second error* vanished. But the third error, viz: that the veins carried blood towards and to the extreme parts was still retained, although, even in the time of Galen, *venesection* was practiced, and the vein was *seen* to swell *below* the ligature, where it was punctured.

Michael Servetus, in a tract entitled "Christianismi Restitutio," (A. D. 1553) describes the *Pulmonary Circulation;* and this is the manner in which so strange a mixture of physiology and theology came to pass.

Servetus was a matter-of-fact man. In Scripture he found it written, "Anima est in Sanguine; anima ipsa est Sanguis." Since the soul is in the blood, says Servetus to himself, to know how the soul is formed we must find out how the blood is formed; to know how the blood is formed, we must see how it moves; and thus in connection with the

revival of Christianity, he is led to the formation of the Soul, from this to the formation of the Blood, and thence to the Pulmonary Circulation.

For his religious tenets he was burned with his books, by Calvin, in Geneva, in 1553, October 27th.

Servetus denied the inter-ventricular pores or canals, but asserted that the blood took a longer course *through* the pulmonary artery into the lung, where it is agitated, prepared, and where it becomes red, and passes from the pulmonary artery into the pulmonary veins. And he gives as a reason, a very fine one, too, for the communication. The pulmonary artery, says he, would not be so large—would not convey so great a quantity of blood to the lungs—if its office were only to nourish the pulmonary tissue; for, in the embryo the lungs derive nourishment elsewhere, since blood does not reach them by this source.

And in another place he says: "In the same manner that in the *Liver* the passage of blood takes place from the portal vein into the vena cava, so also in the lung is effected the transfusion of blood from the arterial vein (pulmonary artery) into the venous artery (pulmonary vein).

A step farther, and the discovery of the double circulation of the blood would have been made.

Six years after Servetus, Realdo Columbo, of Padua, discovered the fact of the pulmonary circulation independently; and in 1593, in Venice, Andreas Cæsalpinus, also of Padua, described, as a discovery of his own, the passage of the blood from the right heart through the lungs to the left heart, and applied to this passage the very word *Circulation*.

But he does not stop at the lesser circle—he goes further. Cesalpin, who first noticed that the veins, in venesection, swell beyond the ligature, expresses his astonishment at the circumstance, when all dogmas affirmed that the blood flowed in the veins from the centre to the periphery. And he then asserts that "The Blood, borne *to the heart by the veins*, receives in that organ its last perfection; and this *supreme quality* acquired, it is carried by the *arteries* into the body everywhere.

He traces the blood in its course from the vena cava through the heart into the lungs, thence into the left ventricle, and finally into the aorta, around the mouth of which and the pulmonary artery he described "*certain membranes*," so adjusted as to prevent retrocession. And then there is a perpetual certain motion from the vena cava through the heart and lungs into the aorta.

And, to repeat, we first meet in Cesalpinus with the distinct expression, Circulation of the Blood.

The idea was expressed, but it remained fruitless with Cesalpin, who neither appreciated its force nor its consequence.

It may well be regarded as surprising that as error after error was disembowelled and cast aside, and a sterling truth substituted for each error—that with the actual fact of the lesser and the greater circulations pointed out—there should still be required anything but the acceptance of the great fact in science. And this, too, when Fabricius d'Acquapendente, in Italy, and a Professor in Padua, had already, in 1574, made the discovery of the valves of the veins—had even found that they opposed the course of the blood *from* the heart, that the blood must proceed to and towards the heart, inversely to what happens in the arteries, which have no valves. Fabricius was even the master of Harvey, who studied in Padua.

The different *parts* of the circulation had been discovered, but the parts remained separate, disjoined and unprofitable. In this discovery, (says Flourens) the difficult point was to connect the divers parts, and, if I may so express myself, the various pieces, successively brought to view, into a *unity*—the difficult point was to seize the comprehensive whole of the phenomenon, of the mechanism. And it is because Harvey is the first who did so grasp, clearly and completely, the phenomenon in its entireness, that the great glory has been awarded to *him*.

Michael Servetus, to whom the discovery of the pulmonary, or lesser circulation is attributed, made, perhaps, a wider step towards the great truth than any of his predecessors.

As his name deserves and receives mention in connection with the Circulation of the Blood, a word as to his life and unfortunate end may not be considered out of place.

Michael Servetus was a native of Arragon, in Spain, and the son of a Notary. He studied Law at Toulouse; but manifesting a stronger affection for Medicine, he studied at Paris, took the Doctor's degree, and subsequently established himself as a practitioner of medicine in Dauphiny. Not content to seek celebrity in medical pursuits, and eager to publish his Arian religious opinions, he sent three "questions" to Calvin, (who may be said to have ruled in Geneva) "on the Divinity of Christ," "on Regeneration," and "on the necessity of Baptism." His ardent disposition changed the peaceful temper of the controversy he had begun into a bitter correspondence; and Calvin became, in consequence, his unrelenting foe.

In 1553 Servetus published a book embracing most of his previous writings, and which had this title: "Christianismi Restitutio," the revival of Christianity; whereupon Calvin caused him to be accused as a dangerous man, and his imprisonment soon followed. Escaped from prison, he attempted to pass through Geneva in disguise, but was seized by the authorities as an impious heretic. The Magistrates, urged especially by Calvin, condemned their prisoner as guilty of forty heretical errors; and upon his refusing to renounce them, was *burnt* at the stake a few months after the publication of his book, on the 27th of October, 1553, and died after two hours torture.

The only two copies of this remarkable work belong to the imperial libraries of Paris and Vienna; and that of Paris is the very same which was used by Colladon, one of the accusers instigated by the implacable Calvin against Servetus. Colladon underlined the propositions which served as the basis of the accusation; and this volume, somewhat scorched by fire, was only snatched from the pile upon which the author and his books were to be burned, when the flames had already begun to ascend.

When Harvery appeared, everything relating to the Circulation of the Blood had been suggested or suspected, but nothing was established. *Servetus* had pointed out the lesser circulation, but knew nothing of the greater. *Columbo* had done nearly the same, but he adhered to the doctrine of *Galen* that the *veins* arise in the liver and convey blood *to* the periphery. *Cesalpinus*, who sees the two circulations, retains the error of antiquity that the ventricular. septum is perforated. And finally *Fabricius* discovers the valves of the veins, but knows nothing about the circulation. None of them had an idea of the torrent of blood which traverses the pulmonary artery and veins in a given time. And if they had conceived it, they would have been sorely embarrassed to tell *whence that blood came, and whither it went.*

Harvey begins with the *motions* of the double *Heart*, and observes that the auricle and ventricle of each heart contract successively. When the auricles contract, (being filled by the veins,) they pour their blood into the ventricles, which then propel their blood into the *lungs*, on the one hand, and into the system at large on the other; and he lays stress on the fact that the aortic and pulmonary orifices are guarded by "little gates," "ostiola." or valves, which prevent regurgitation during the diastole of the ventricles.

Then he proceeds to show that the *arterial pulse* is due to the distending force of the blood urged by the heart; and proves, by opening an *artery* in a living animal, that while the blood issues *in jets*, these are strongest in the *diastole* (or distension) of the *artery* than during its *systole.*

Harvey also noticed, in connection with *arteriotomy*, that all the blood (as he expresses it) of an animal will flow out of a wounded artery; wherefore heart, arteries and veins must communicate with one another.

How could it be otherwise, in view of the great rapidity of the circulation? says the great Englishman who now makes that celebrated calculation. Suppose that the heart propels, at each pulsation, three ounces of blood, of which the valves prevent the retrocession, that heart which in a half hour makes more than a thousand pulsations, and sometimes even

four thousand. In a half hour, therefore, more than five hundred ounces of blood will pass from the arteries into the veins; a mass more considerable than the entire capacity of the body.

If, instead of a half hour we suppose an hour, a *day*, the quantity which would pass through the heart would be greater than could be furnished by the food in the same period. Wherefore the blood passes not once, but *several times* through the heart in a given time. (Exercitationes, page 89.)

From the *arteries* Harvey proceeds to the *veins*, and draws full consequences from the fact that their valves open in *one* direction only, and allow a current tending *towards* the *heart*. He constricts a member slightly, and the veins, being superficial, swell up—he firmly binds the member, and the course of the blood is arrested because the deeper seated arteries are compressed.

When he ties a vein, it swells below or beyond the ligature; if an artery, it dilates above the ligature. The blood, therefore, moves in the veins and in the arteries in opposite directions; in *the veins* it courses *from* the body *to the* heart, and in the *arteries* it flows from the heart into the body everywhere. This movement, this continual exit and return of the Blood is the Circulation.

William Harvey was born (in England as you are all aware) April 2d, 1578. At the age of nineteen he travelled through France and Germany, and, attracted by the reputation of Fabricius d'Acquapendente, he proceeded to Padua, and applied himself to the study of Medicine under that great master. He returned to London with all the information upon the subject of the circulation of the blood which could then be gathered. In 1615 he was made *Lecturer* on Anatomy and Surgery; in 1616 he laid open the discovery of the circulation of the blood in his lectures, and in 1628 his famous "Exercetatio Anatomica de Motu Cordis and Sanguinis," his masterpiece, and dedicated the work to Charles I., after having verified the statements it contained by many years experiments.

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Having, then, says the distinguised Flourens, demonstrated the circulation of the blood; but he comes from *Padua*, where he had for his master Fabricius, of Acquapendente, who had discovered the valves in the veins; but in this same University of *Padua*, where the first germ of all Harvey's ideas had its birth, Realdo Columbo had recently held a Professor's Chair, he who, six years subsequently to Servetus, had discovered the pulmonary circulation; and not far from Padua lies *Pisa*, where Cesalpin, in a burst of genius, more than suspected the pulmonary circulation, and in another inspiration perceived the general circulation.

All, however, was rude, vague and unsettled—all doctrines were discordant; and it is the great glory of Harvey that he brought order out of chaos, that he held fast to truth and made it his own—that he found his truth in observation and established it by experiment—thus practically he discovered the most beautiful phenomenon of the animal economy. Men no longer swore by *Galen*, they swore by *Harvey*.

The circulation of the blood, the passage of the blood from the arteries into the veins, had been proven and established as a fact by Harvey, but the *direct* demonstration was wanting. It came at last, the *microscope* afforded it; but it was denied to the grand old age of Harvey, who died without witnessing it. In 1661 Malpighi *saw* the blood pass from the arteries into the veins in the mesentry, the lung and the urinary bladder of frogs. The matter was still more clearly exposed in 1668 by Leeuwenhoeck, and later still by G. Cowper. So that now, against *ocular demonstration*, objection raised its voice in vain.

The Sixteenth Century, gentlemen, was a noble era in art and science. It was the age of Raphael, Michael Angelo, and Leonardo da Vinci—of Titian, Guido and Corregio—Ariosto and Tasso sang with inspired lips, and Shakspeare,

Prometheus like, stole fire from heaven to vivify his creations. Artillery was first used, and modern warfare had thus its beginning under Francis I. at the commencement of this century; and the *silken ligature*, invented by the renowned Ambrose Paré, towards its conclusion, first arrested hemorrhage. The microscope and telescope were sketched out just before the close of this epoch; while in the very middle of the Sixteenth Century the circulation of the blood was first announced to the world. But the *real* discovery of the circulation, of the circulation of the blood as a practical, substantial thing, as the starting point of Modern Physiology, was reserved for *Harvey,* the Great Harvey, in the beginning of the Seventeenth Century.

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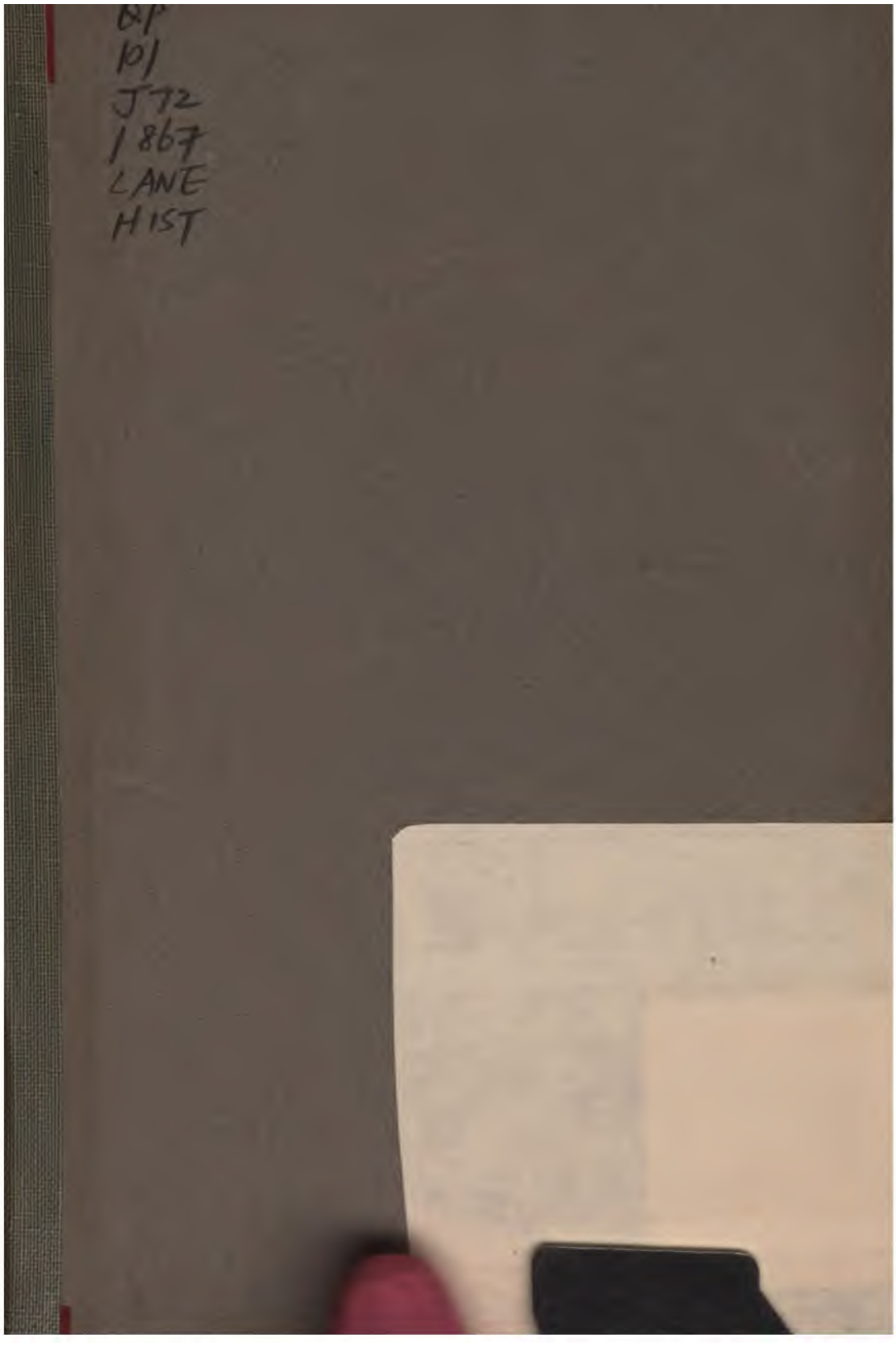
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